5

AIRCRAFT CIRCULARS

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

No. 147

THE BERNARD 80 G.R. LONG-DISTANCE AIRPLANE (FRENCH)

A Two-Place Cantilever Monoplane

Washington
July, 1931

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

AIRCRAFT CIRCULAR NO. 147

THE BERNARD 80 G.R. LONG-DISTANCE AIRPLANE (FRENCH)*

A Two-Place Cantilever Monoplane

By Pierre Léglise

The search for the best penetration shape led to the adoption of a very long fuselage (figs. 1, 13, 14 and 15) having the smallest midsection compatible with the comfort of the crew for a flight of 80 hours. The fairing of the radiator under the fuselage is about 2 m (6.56 ft.) long, thus reducing the formation of eddies and increasing the efficacy of the radiating surface. The Bernard method of enlarging the wing in the middle made it possible to construct a light cantilever wing by taking advantage of the opportunity to give to the central portion the maximum volume and hence the maximum moment of inertia, the height being limited only by the dimensions adopted for the fuselage. Moreover the wing and fuselage can be joined under excellent conditions of strength and form. The wheels have streamlined shields whose shape was determined by systematic wind-tunnel tests. The fineness of the airplane is about 17.5. This value was determined by numerous tests with the actual airplane, a constant angle of attack being adopted for each test. The total flying weight, the measured speed and the r.p.m. being known, each test yields a point of the polar. The only element of uncertainty is in the calculations of the propeller, whose efficiency and absorbed energy are known only by the α, β, γ curves of a model furnished by the manufacturer. The points obtained by the observations, though distributed in a somewhat disorderly manner, made it possible to plot a curve probably very near the actual polar. The maximum value of the ratio C_z/C_x was measured on this curve.

The wing tapers greatly in both width and thickness and has elliptical tips (fig. 8) joined to the leading and trailing edges by parabolic arcs. The profile has a simple

---

*From L'Aeronautique, June, 1931, pp. 197-201.

camber: minimum 100 C_x of wing, 2.35; corresponding lift, 25; fineness of wing alone measured in wind tunnel, 21.8; 100 C_z maximum, 142; C_{m_0} of wing, 2.75. An especially small value was sought for C_{m_0} in order not to have to fear the vibrations in a cantilever wing with a half-span of 12.25 m (40.19 ft.).

The two box spars have spruce flanges and plywood webs. In the central enlarged part of the wing (fig. 6), the flanges consist of spruce strips 5 mm (0.2 in.) thick, given the desired contour and glued under pressure, their width and thickness being uniform. Between the curved flanges of the spars there is an orifice 0.7 m (27.56 in.) high by 0.45 m (17.72 in.) wide, affording communication between the pilot's station in front of the front spar and the navigation room behind the rear spar. The contour of each passage consists of an elliptical spruce frame, against which the inside of the flanges of the central part of each spar is braced. In Figure 6 the numbers 1, 2, 3, 4 indicate the passages for the fuselage longerons. The scale is only approximate.

The laminated flanges of the central part are joined to the plain flanges of the wings proper by long grafts. The plain flanges are planed to fit the wing profile. Their thickness and width decrease toward their tips. The webs are cross-braced by openwork ribs of plywood.

There are both box ribs and plain ribs. The box ribs (fig. 5) have double spruce flanges, each element being 5 mm (0.2 in.) thick, and plywood cross braces joined by quarter-rounds to the lower flange. This structure is held together by two openwork plywood webs 1.5 mm (0.06 in.) thick. The upper flange and webs are held together by a spruce capping 10 mm (0.4 in.) thick on the sides. Passages are left in the double flange for longitudinal spruce members (of I section) which support the plain ribs.

In the central part of the wing the enlarged elements of each spar are joined by four strong horizontal tubes and two oblique tubes forming two N's in two vertical planes. (Figs. 4 and 12.) The front and rear parts of the fuselage are joined to the four sockets at the corners of a square 1 m (39.37 in.) on a side, according to the Bernard method as already described in L'Aeronautique of December, 1930, p. 427. (N.A.C.A. Aircraft Circular No. 139.)

The wing is covered with plywood which, in turn, is covered with fabric. The plywood has a thickness of 1.5 mm (0.06 in.) on the leading edge and 3 mm (0.12 in.) between the spars. The ailerons are near the wing tips. They have no terminal balancing projections in order to avoid starting vibrations. The aileron spar is hinged to an auxiliary spar supported by the ribs and connected at the wing tips with the rear wing spar. The trailing edge between the fuselage and the ailerons consists of two removable boxes. (Fig. 4.)

The oval rear part of the fuselage consists of four longerons joined in pairs by vertical and oblique frames which support a system of longitudinal members. The two vertical girders thus formed (fig. 7) constitute the principal resisting structure of the fuselage. The covering is plywood faired above and below. Each part of the fuselage is joined to the wing by four main sockets in the ends of the tubes connecting the wing spars. Two secondary attachments are also provided at the top and bottom of the fuselage in its plane of symmetry. The navigation room, situated aft of the rear spar, is 2 m (6.6 ft.) long and 1 m (3.3 ft.) wide. Observations can be made through two side windows and an overhead opening.

The front part contains the pilot's station accessible through triangular doors with glass windows which afford sufficient visibility for cruising. The seat is adjustable in height (fig. 12) for difficult maneuvers near the ground or in disturbed air.

The engine bearer of duralumin tubing resembles that of the Bernard 191 G.R. The 350 liter (92.5 gal.) oil tank is between the engine bearer and the pilot's station.

Under the fuselage the elongated fairing of the water radiator is provided with vertical slots, like the hood of an automobile with shutters in front to regulate the temperature. The Bernard Company has found this device preferable to a retractable radiator.

The horizontal empennage has a triangular shape with elliptical ends and a large aspect ratio. The stabilizer is adjustable in flight by turning it about hinges on its rear spar. The tail surfaces are covered with plywood and fabric.

Each half of the landing gear consists of a fork (fig. 9), with two box panels, attached by two hinges to the bottom of a specially reinforced box rib. The spindle moves in two guides closed by a piece which permits the mounting of the wheel. The front and rear openings are closed by suitable fairings. Each fork weighs 29 kg (64 lb.) and can support 20 metric tons (44092 lb.). The shock-absorbing system consists of loops of rubber cord (sandow rings) attached on the one hand to the edges of the box panels (stress distributed by the inner walls) and on the other hand to a vertical strut containing an oil brake for the recoil. The bent axles are hinged to a fixed point in the plane of symmetry of the airplane. This point (fig. 12) which is concealed in the fairing behind the water radiator is formed by the junction of four tubes supported by the bottom of the longerons. It is also supported by an iron fitting in the axis of the airplane. Due to the great width of the track, 4 m (13.12 ft.), the angular displacements of the wheel with respect to its mean plane of rotation are insignificant. The fairings have been the subject of numerous comparative tests and have been refined to the greatest possible degree in the vicinity of the junctions of the forks with the lower side of the wing.

The 80 G.R. can carry 7100 liters (1876 gal.) of fuel in 10 wing tanks holding 500 to 600 liters (132 to 158.5 gal.) each, one 700 liter (185 gal.) tank in the enlarged part of the wing and a 150 liter (39.6 gal.) header or collector tank in the bottom of the fuselage. Each wing tank of the duralumin partitioned type is placed between two box ribs and supported by bands or straps of spring steel (fig. 2) attached to the spars. Each strap is secured to the top of the tank by a bolt s. The tank compartments are covered on top by plywood panels attached to the spars and box ribs by duralumin plates (fig. 3) and on the bottom by a box flooring through which the Mauve quick-emptying cock passes.

Because of the depth of the wing tanks and their relative distance from the wing covering it did not appear necessary to join the air inlets and make them issue at a high point in the fuselage. Each tank has an air tube opening under the plywood top. The tanks are joined in pairs 1 and 1' to 5 and 5' (figs. 10 and 11), by flexible pipes and empty, like the central tank N, into the collector C, whose rear side has six control cocks. (Fig. 11.) From the collector, which is provided with an inde-

pendent air vent opening into the upper part of the fuselage, the fuel is drawn by the pumps and a Malivert injector I, enabling, aside from the injection of fuel in starting, the removal of the water collected at D. The bottom of the collector is connected by a flexible pipe to a cylinder c surmounted by a glass tube T. The cylinder c contains a float with an index stem which can glide inside of T. The relative positions of c and C are such that when the latter is full the float just touches the top of the former.

When taking off the collector is full and a single drain cock is open. (The wing tanks are emptied successively in pairs and the fuselage tank last.) The pressure due to the fuel in the tanks pushes the float against the top of the cylinder c while C is being supplied with fuel from the two wing tanks. When the fuel level in C begins to sink the falling of the index in T warns the pilot that the first two tanks are empty and that he must open the second cock. The pilot is thus informed six times of the exact quantity of fuel remaining.

The oil tank is located between the pilot's station and the engine. It also has a glass gauge which is sufficiently accurate since the oil tank is deep. The oil radiator is situated on the left side of the fuselage at the level of the middle of the tank.

Characteristics

with 650 hp Hispano-Suiza 12 Nb engine

Span	24.5	m	80.38	ft.
Length	14.8	"	48.56	"
Height	4.0	"	13.12	"
Wing area	70	m^2	753.47	sq.ft.
Weight empty	3100	kg	6834.32	lb.
Weight loaded	8625	"	19014.85	"

Performances

Maximum speed	250	km/h	155.34	mi./hr.
Cruising speed	185	"	114.95	"
Radius of action (theoretical)	13000	km	8077.8	mi.
Ceiling with full load (theoretical)	2500	m	8202	ft.

Translation by Dwight M. Miner,
National Advisory Committee
for Aeronautics.

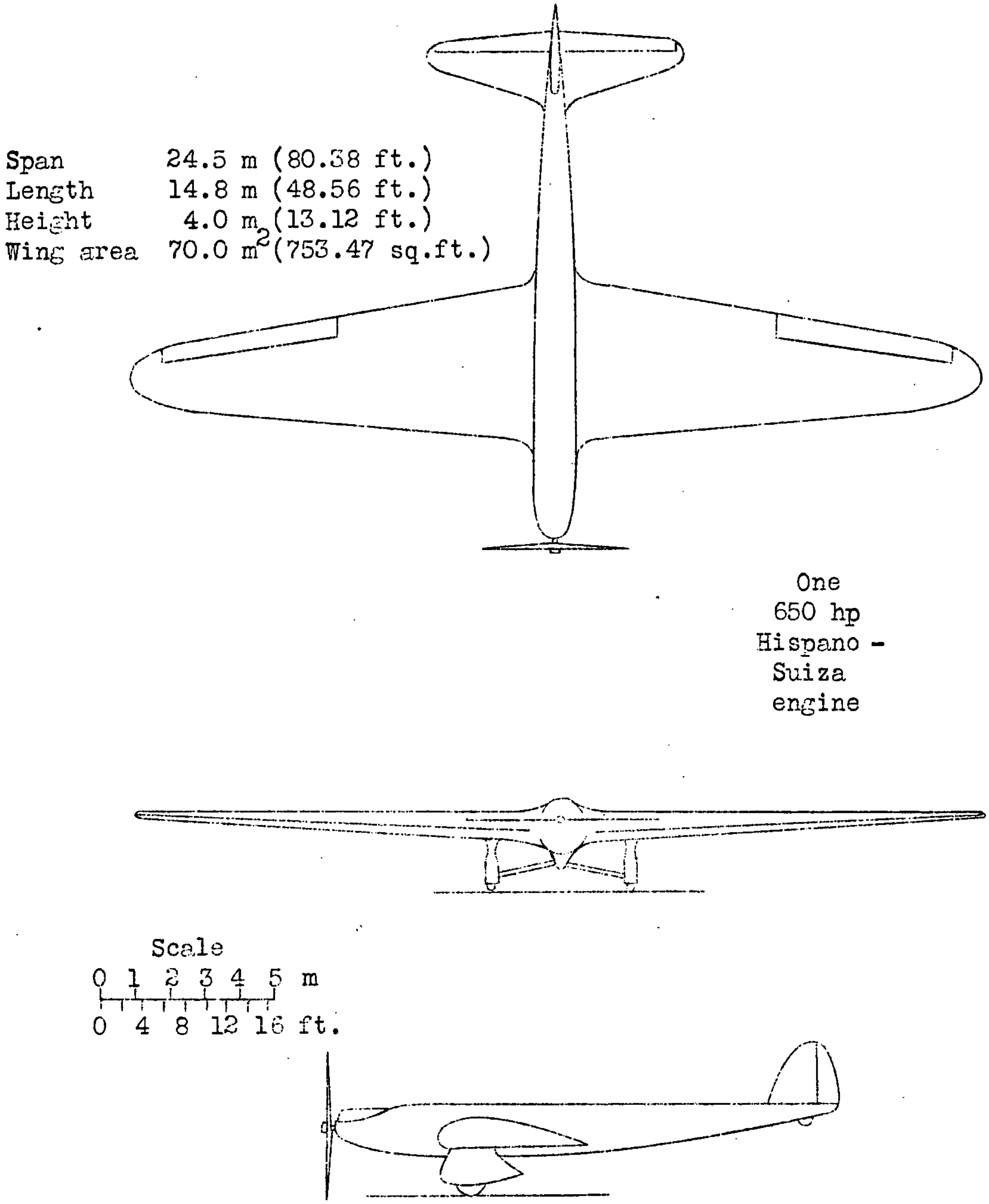


Fig.1 General arrangement drawing of the Bernard 80 G.R. airplane.

Fig. 2.

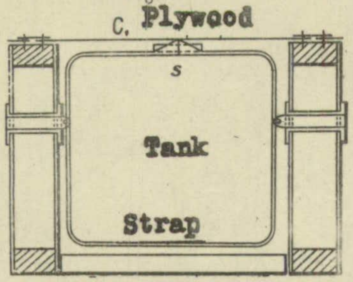


Fig.2 Wing tank between spars.

Fig. 3.

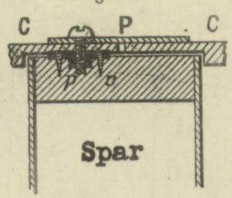


Fig.3 Attachment of plywood panels to top of spar.

Fig. 4.

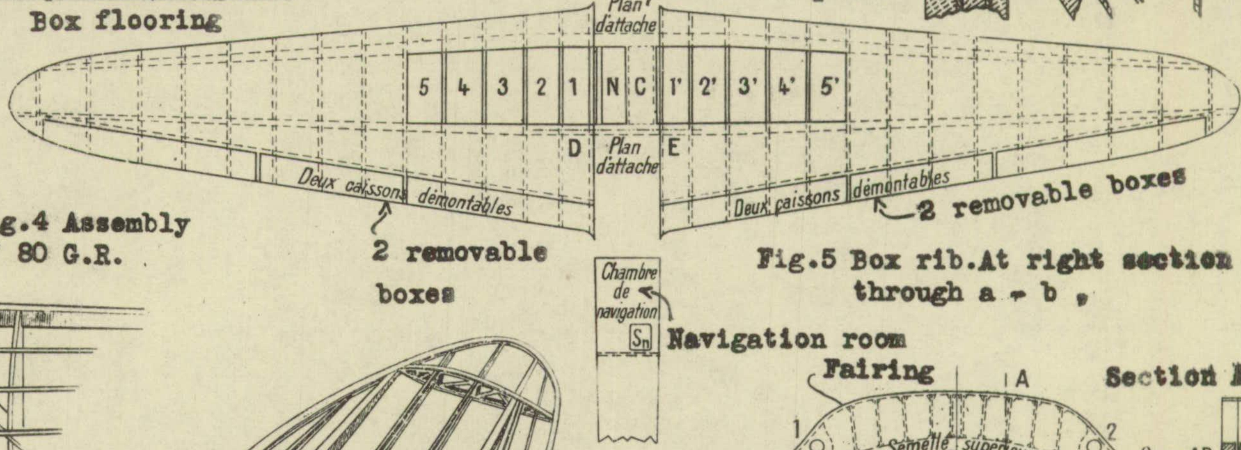


Fig.4 Assembly of 80 G.R.

Fig. 5

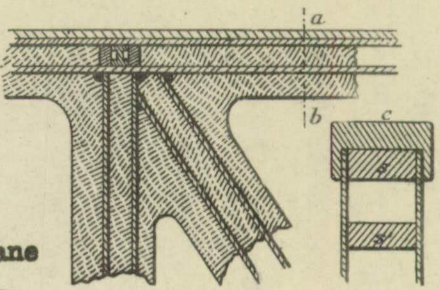
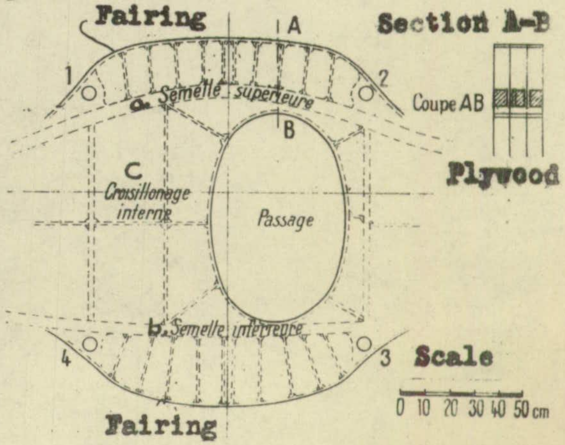


Fig.5 Box rib. At right section through a - b,



a, Upper flange

C, Interior bracing

b, Lower flange

Fig.6 Section in median plane of rear spar.

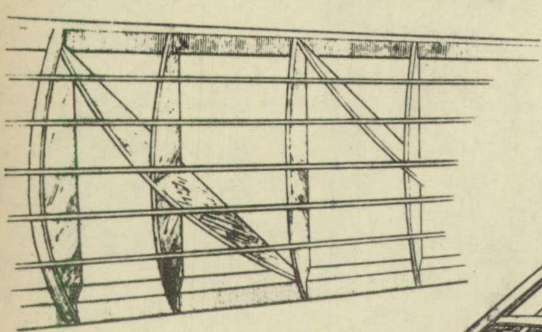


Fig.7 Portion of vertical girder of rear part of fuselage.

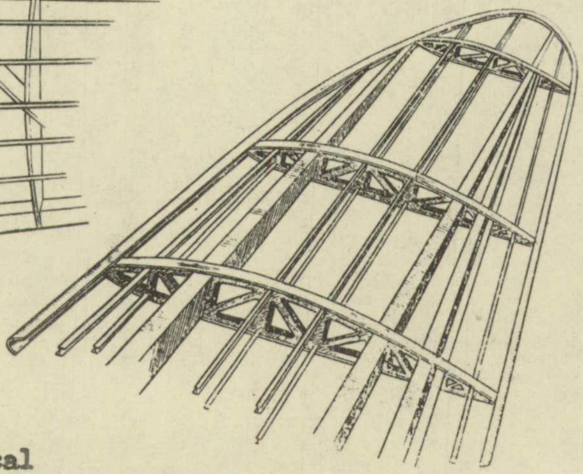
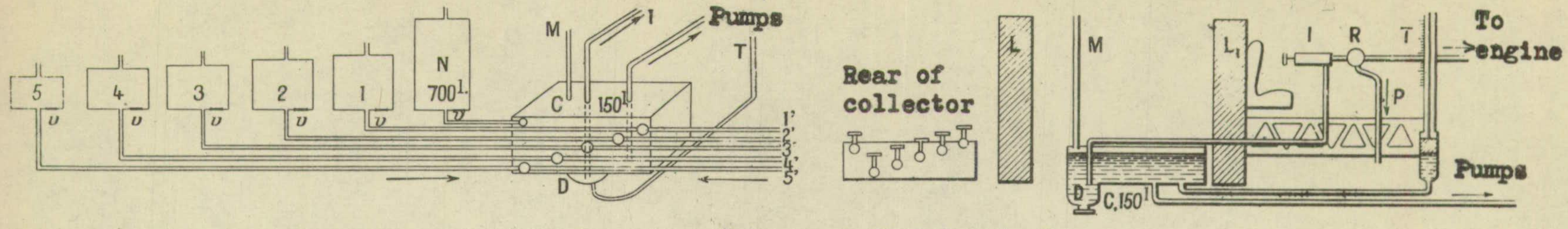


Fig.8 Wing tip.



Figs.10,11 Fuel system of Bernard 80 G.R. airplane.

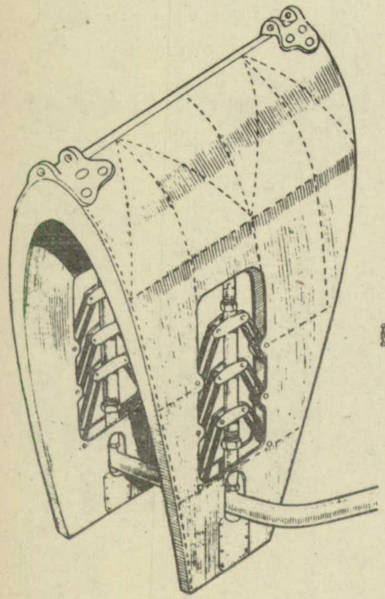
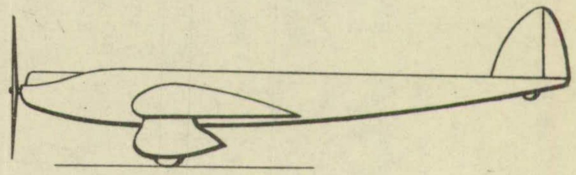


Fig.9 Landing-gear fork.



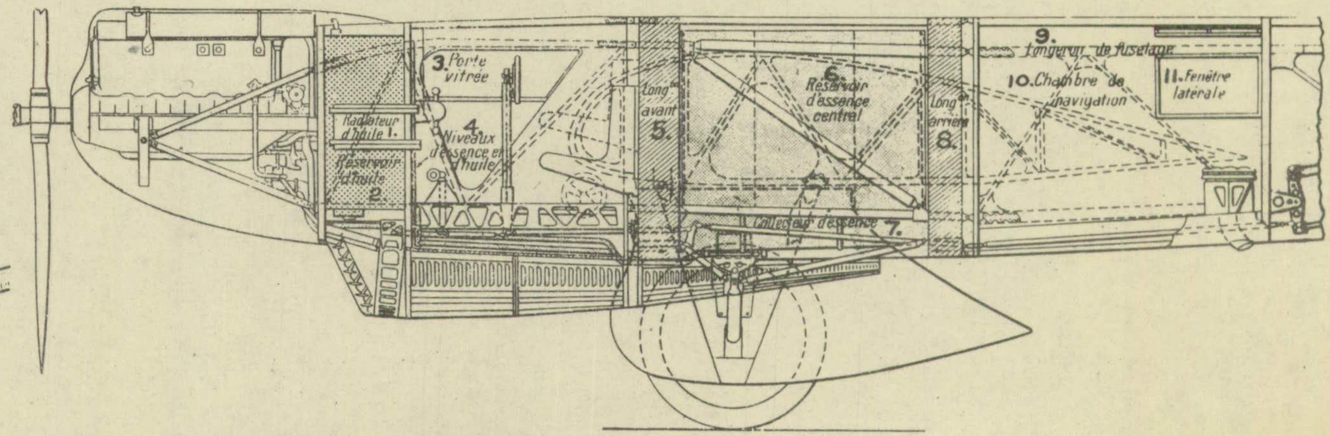
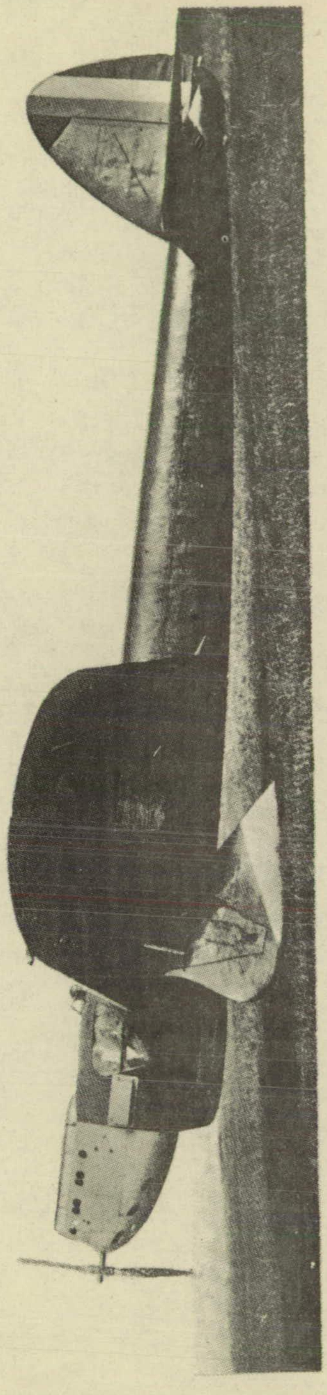
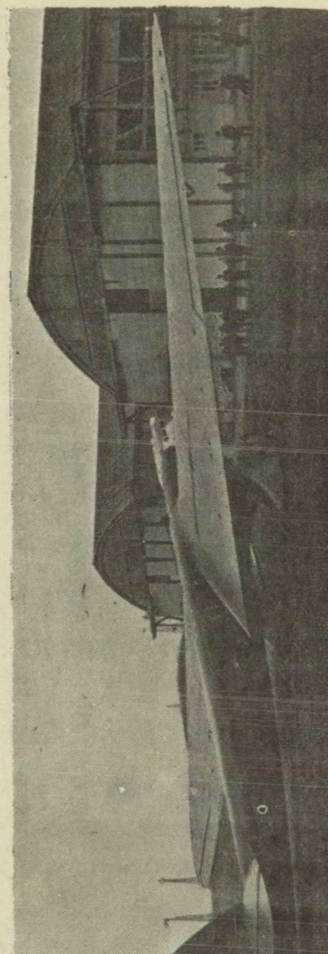


Fig.12 Longitudinal section of Bernard 80 G.R. Scale about 1/40. First rib is shown in dash lines.
1. Oil radiator. 2. Oil tank. 3. Glass door. 4. Fuel and oil gauges. 5. Front spar.
6. Central fuel tank. 7. Collector fuel tank. 8. Rear spar. 9. Longeron.
10. Navigation room. 11. Side window.





Figs.13,14,15 Bernard 80 G.R. with 650 hp. Hispano-Suiza engine.